MEMORANDUM

To: Big Dry Creek Watershed Association Board of Directors

From: Wright Water Engineers, Inc.
Jane Clary

Date: March 12, 2008 *(finalized April 10, 2008)*

Re: Big Dry Creek Water Quality Summary for 2007

This memorandum summarizes the water quality monitoring program conducted by the Big Dry Creek Watershed Association (BDCWA) during 2007, including these topics:

- Data summary and comparison to stream standards
- Key constituents of interest
    a. Bacteria
    b. Selenium
    c. Iron
    d. Others (e.g., nutrients, temperature)
- Flow conditions
- Quality assurance/quality control

Data Summary

During 2007, the City and County of Broomfield and the cities of Northglenn, Thornton, and Westminster (Cities) worked together to collect water quality and flow data along the main stem of Big Dry Creek (Figure 1). Water quality samples were analyzed for a variety of constituents, resulting in over 3,200 records being added into the BDCWA water quality database. Metals were monitored on a quarterly basis with the exceptions of iron and selenium, which were monitored monthly. All other constituents were monitored on a monthly basis. The Cities and BDCWA also helped to fund operation of the U.S. Geological Survey (USGS) gauging station at Westminster behind Front Range Community College. Key findings related to the 2007 data are the subject of this memorandum.

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Four summary tables and multiple figures are attached to this memorandum providing key supporting information for purposes of this annual water quality review, including:

1. Table 1 identifies the Colorado Water Quality Control Commission (CWQCC) stream standards on Segment 1 of Big Dry Creek, the frequency with which standards were exceeded and whether the stream attained the standard for each constituent.

2. Table 2 provides a summary of the numbers of samples collected and the average, minimum and maximum concentrations for each constituent at each monitoring location. The relevant regulatory statistic (e.g., 85th percentile) for constituents with stream standards is also provided.

3. Table 3 provides a summary of the quality assurance (QA) sampling and analyses conducted during 2007.

4. Table 4 provides a summary of *E. coli* data for 2001 through 2007. *(Note: this small table is located in the text of the report, whereas all other tables are located in the Tables section at the end of the report.)*

Attachment 1 provides a summary of the data collected during 2007.

As a general note, the Big Dry Creek monitoring program is an ambient-based program. Ten of the twelve sampling dates occurred during dry weather conditions, the February sampling event followed a large snowstorm, and the May sampling event followed a rainfall event.

SUMMARY OF COMPARISON TO STREAM STANDARDS

Attainment of stream standards is evaluated based on comparison of specific statistical values to chronic stream standards and determining whether acute standards are exceeded in any samples. For most constituents, the relevant statistic for comparison to the chronic standard is the 85th percentile value. Exceptions include use of the 50th percentile value for metals with standards in the total recoverable form, the geometric mean[1] for *E. coli* and fecal coliform, and the 15th percentile value for dissolved oxygen (DO) and the lower acceptable range for pH. (*It should be noted that from a regulatory perspective, five years of data would be used in such a comparison*.)

In keeping with the Colorado Water Quality Control Division (CWQCD) current wastewater discharge permits for Broomfield and Westminster, a hardness value of 256 milligrams per liter (mg/L) was used to calculate the hardness-based stream standards. The CWQCD used a value of 359 mg/L for the City of Northglenn's permit. The mean hardness value for the stream as a whole

[1] The geometric mean is calculated as the nth root of the product of n values. The geometric mean is used for regulatory purposes because it lessens the impact of extremely high or low values, relative to the arithmetic mean.

during 2007 was 390 mg/L. Figure 2 shows relatively high hardness values upstream of the wastewater discharges, as well as in the lower portion of the creek in the agricultural area.

Segment 1 (the main stem) of Big Dry Creek is listed on the 2008 303(d) List for Colorado for non-attainment of stream standards for *E. coli* and selenium. Prior to 2008, both of these constituents had a temporary modification to the stream standard in place. At the December 2007 "Temporary Modifications" hearing, the CWQCC removed the temporary modification for *E. coli* and assigned a site specific standard for selenium, based on work completed by BDCWA. The site-specific standard for selenium became effective March 11, 2008, whereas the 303(d) List for 2008 was based on assessment of standards that were effective as of February 11, 2008. Due to administrative timing issues, Big Dry Creek is still on the 303(d) List for selenium. Prior to 2008, a portion of the stream downstream of the Weld County line was listed on the Monitoring and Evaluation (M&E) portion of the 303(d) List for total recoverable iron; however, this stream segment has been removed from the M&E List for iron. Based on review of the 2007 BDCWA data set, a summary of findings related to these listings includes:

- Selenium: At the December 2007 CWQCC Hearing, irrigation and non-irrigation season site-specific standards were assigned to Big Dry Creek. A specific standards assessment method was also developed that is to be based on data collected at monitoring locations bdc1.5, bdc2.0, and bdc4.0 (i.e., the instream locations upstream of the wastewater treatment plant discharges). The 2007 Big Dry Creek data set meets the non-irrigation season (winter) standards; however, the 2007 irrigation season 85^{th} percentile value (7.9 µg/L) is slightly above the irrigation season standard (7.4 µg/L). Attainment of the stream standard will ultimately be based on five years of data. A full five-year data set for the irrigation season will be complete in July 2008. (See the selenium discussion below for more information.)

- *E. coli:* The geometric mean for the overall stream segment exceeded the stream standard during 2007, consistent with the past five years of data at this location. Special studies related to sources of *E. coli* in the watershed were conducted during 2007 and will continue through 2008.

- Iron: The total recoverable iron 50^{th} percentile value for the stream as a whole met the stream standard of 1 mg/L during 2007.

- All other constituents attained the stream standards during 2007.

More detailed discussion for key constituents follows.

Selenium

In December 2007, the BDCWA, the CWQCD and the U.S. Environmental Protection Agency (USEPA) worked together to develop an ambient-based site-specific standard for Big Dry Creek based on the "natural or irreversible human-induced conditions" related to selenium on the creek. As a result, the stream standards for selenium on Big Dry Creek changed from a chronic stream standard of 4.6 µg/L and acute standard of 18.4 µg/L to seasonal ambient-based standards. (The complete study on which this standard is based can be downloaded from the Big Dry Creek website

www.bigdrycreek.org.) The new standards and method of assessing attainment of the standards are described in the Statement of Basis and Purpose in Regulation 38 (CWQCD 2008a) as:

> *The Big Dry Creek Cities presented evidence that the natural or irreversible human-induced ambient water quality levels for selenium in Big Dry Creek Segment 1 at times exceed the relevant table value standard, and an ambient quality based standard, calculated in a manner consistent with Basic Standards requirements, is adequate to protect classified uses. The Commission accepts the Big Dry Creek Cities' evidence as accurate. The Commission expressly finds that the natural or irreversible human-induced ambient water quality levels for selenium in Big Dry Creek Segment 1 exceed the relevant table value standard. Moreover, the proposed ambient quality based standard is adequate to protect classified uses and represents the highest reasonably attainable standard, based on analysis of available data that show elevated instream conditions are attributable to natural or irreversible human induced conditions.*
>
> *Strong seasonal variation associated with highly managed flow conditions (e.g., releases of irrigation water from Standley Lake) significantly influences selenium concentrations, particularly in the portion of the stream above the wastewater treatment plants. As a result, the Commission adopts seasonal ambient quality based site-specific standards for selenium applicable to Big Dry Creek Segment 1. During the irrigation season (April through October), ambient standards are 7.4 µg/L chronic (dis) and TVS µg/L acute (dis). Ambient-based non-irrigation season (November through March) standards are 15 µg/L chronic (dis) and 19.1 µg/L acute (dis). These calculations are based on the 85% (chronic) and the 95% (acute for the non-irrigation season) of the ambient selenium data collected at three specific instream monitoring locations (bdc1.5, bdc2.0 and bdc4.0) upstream of the three municipal wastewater treatment plant discharges, however, it is the Commission's intent that the existing spatial variability of selenium in Big Dry Creek be maintained. This composite approach was jointly developed by the Cities and the Water Quality Control Division as a reasonable method to establish the ambient based standards and to assess attainment of future stream standards for Segment 1 of Big Dry Creek. The ambient quality based site-specific standards for selenium (acute and chronic) shall apply to the entirety of Big Dry Creek Segment 1. The Commission also removes the temporary modification currently in place for selenium in Big Dry Creek Segment 1.*

Based on these revised standards, the 2007 data set attains the non-irrigation season (winter) standard for Big Dry Creek. The irrigation season data set for 2007 is slightly above the irrigation season (summer) chronic standard. Specifically, the 85th percentile value at bdc1.5, 2.0, and 4.0 during 2007 is 7.9 µg/L, as compared to the 7.4 µg/L chronic standard. This is primarily due to high selenium values at bdc1.5 during the "fringe" of the irrigation season (i.e., April and October) when dilution flows from Standley Lake are tapering off. (See Figures 3, 4a, and 4b.)

From a regulatory perspective, attainment of the stream standard would be based on five years of data. Currently, the Big Dry Creek data set includes five complete non-irrigation seasons, and between four and five irrigation seasons. The 85th percentile at bdc1.5, 2.0, and 4.0 for the irrigation season during the past four to five years is 7.74 µg/L, also slightly above the irrigation stream

standard. The reason for this slight (0.34 µg/L) excursion above the irrigation stream standard is believed to be due to the relative weighting of months of available data for the irrigation season data sets. Specifically, the data set currently includes only four seasons of data for April through July, which tend to have lower selenium values; whereas, the data set includes five seasons of data for August through October. October tends to have higher selenium values (e.g., values of 17, 9, 15, 6, 15 µg/L at bdc1.5). In contrast, the data set on which the irrigation stream standard was based included four complete seasons of data, with each month equally weighted (August 2003 through July 2007). Five complete irrigation seasons will be complete as of July 2008, provided that monthly monitoring of selenium is reinstated, as opposed to a quarterly sampling program. In September 2008, selenium monitoring can be reduced down to the quarterly monitoring schedule as originally planned by the BDCWA Board, consistent with the monitoring program for other metals in the creek. (This quarterly schedule is based on sample collection in March, June, September, and December.)

Bacteria

From 2001 through 2005, the Basic Standards contained a dual standard for fecal coliform and *E. coli*; the standard was changed to solely *E. coli* in June 2005 (CWQCC 2005). In March 2007, BDCWA stopped monitoring for fecal coliform and now monitors *E. coli* only. BDCWA now has eight years of *E. coli* data collected on a monthly basis at eight instream locations, as well as grab samples from the wastewater treatment plants (WWTPs) (Table 4 and Figures 5 through 7). From a regulatory perspective, data collected from 2003 through 2007 would be considered in evaluating attainment of the *E. coli* stream standard. Historic data from 2000 through 2002 are provided in Table 4 to show the influence of the drought on *E. coli* concentrations. The historic data are also of interest to show significant reductions in the Broomfield WWTP's effluent concentrations following WWTP upgrades and expansion in the 2001-2004 time period.

Table 4
Summary of Big Dry Creek *E. coli* Data

Geometric Mean *E. coli* (#/100 mL)										
Year	**bdc0.5**	**bdc1.0**	**bdc1.5**	**bdc10.0 (Broom. WWTP)**	**bdc2.0**	**bdc11.0 (West. WWTP)**	**bdc3.0 (I-25)**	**bdc4.0**	**bdc5.0**	**bdc6.0**
2000	212	151	389	--	574	--	294	500	212	323
2001	477	118	332	215	649	68	387	634	442	510
2002	858	230	363	364	934	16	536	441	451	572
2003	191	210	293	27	615	24	382	225	249	339
2004	279	181	217	18	346	28	205	187	156	377
2005	152	122	281	26	328	35	204	113	182	301
2006	76	241	316	20	309	48	214	163	179	333
2007	196	177	257	14	324	66	230	231	198	364

Notes: Broom. = Broomfield; West. = Westminster; Northglenn excluded due to infrequent discharge. For consistency between sampling years, the 2003 weekly samples were converted to monthly geometric means prior to calculating the annual geometric mean for 2003.

Based on review of the data, the following observations are noteworthy and are included both in this annual water quality report, as well as in a special *E. coli* study report released to the BDCWA Board for review in January 2008:

- Based on review of geometric mean concentrations from 2003-2007, *E. coli* concentrations are consistently the lowest in grab samples from the Broomfield and Westminster WWTP discharges (Figure 5), which are well below the stream standard.

- Half of the instream monitoring locations had geometric mean *E. coli* concentrations above the stream standard. The highest geometric mean concentration of *E. coli* is present at bdc2.0, below the Broomfield WWTP (Figures 5 and 6). Monitoring station bdc6.0 in the agricultural area upstream of the confluence with the South Platte River had the second highest concentrations.

- The 2007 *E. coli* geometric mean concentrations were within the ranges of historically reported geometric means at each monitoring location.

- Seasonal variation is evident (Figure 7) for the 2003-2007 *E. coli* data set, with geometric mean concentrations above the stream standard during April through October.

- For most locations on the stream, *E. coli* concentrations are about one-quarter to one-half of those measured during drought conditions in 2002, with the exceptions of bdc1.0 and bdc.1.5, which appear to be less variable over time (Table 4).

Dry weather sampling at stormwater outfalls between 112th (bdc1.0) and 128th (bdc2.0) Avenues was conducted in April and October 2008. Results of these sampling efforts are contained in a separate draft report, which will be supplemented with additional dry weather sampling between 128th Avenue and I-25 in April 2008.

Iron

Total recoverable iron concentrations during 2007 attained the stream standard of 1 mg/L based on the 50th percentile value for the overall stream. All individual monitoring locations also met the standard, with the exception of bdc5.0 (Figure 8). About 30 percent of the samples collected (i.e., 27 out of 92 samples) exceeded the standard, with the highest concentrations corresponding to runoff from a large snowstorm in February (Figure 9). Other elevated concentrations in the lower watershed (agricultural area) occurred during the irrigation season and could be associated with irrigation return flows and/or unstable banks in this area (Figure 9). As shown in Figure 10, total recoverable iron and total suspended solids are well correlated to each other, as has been the case in previous years.

As previously noted, in 2008, the CWQCD removed Segment 1 of Big Dry Creek from the Monitoring and Evaluation List. Given that the overall stream segment meets the iron standard, BDCWA concurs that this was an appropriate decision.

Other Constituents

Ammonia

Stream standards for ammonia on Big Dry Creek are undergoing changes. In June 2005, the CWQCC adopted revised ammonia criteria for the Basic Standards based on EPA's *1999 Update of Ambient Water Quality Criteria for Ammonia*. The new criteria are in the form of total ammonia and are more stringent for warm water streams than the previous standards. During the March 13, 2007 Rulemaking Hearing, the WQCD proposed temporary modifications to WWTP discharge permits, including the cities of Broomfield, Westminster and Northglenn to remain at the "old" ammonia standard until December 31, 2011. This proposal was based on the CWQCC's acknowledgement that there is substantial uncertainty regarding the appropriateness of and cost of compliance with the new criteria. The temporary modification allows time to reassess what standards are appropriate on a site-specific basis and also provides dischargers additional time to address treatment facility modification that may be needed (CWQCD 2007). Total ammonia concentrations for Big Dry Creek are plotted in Figure 11. Dr. Bill Lewis at University of Colorado has conducted a more detailed analysis of the total ammonia standards for the wastewater dischargers on Big Dry Creek. CWQCD staff are currently reviewing his analysis.

For the currently applicable stream standards, unionized ammonia concentrations were well below the "old" stream standards in 2007, as shown in Figure 12. This is consistent with the data set for the past five years. The grab sample from the Broomfield WWTP effluent on November 8, 2007 was elevated at 7.12 mg/L (the daily maximum permit limit is 7.2 mg/L). Per follow-up correspondence with the City and County of Broomfield, Broomfield exceeded the permit limit

during this time due to failure of three mixers in one of the two anoxic basins. To repair this problem, one of the basins was temporarily shut down, resulting in elevated ammonia in the discharge during that time (Personal Communication with Lesa Julian, City and County of Broomfield).

Nitrate

Although Big Dry Creek does not have a drinking water classification or a corresponding in-stream nitrate standard, the Middle South Platte River Segment 1 downstream of Big Dry Creek has a drinking water classification and a nitrate standard of 10 mg/L. This standard is applied based on a single day combined total of nitrite and nitrate at the point of intake to the domestic water supply. Figure 13 shows that, at the confluence with the South Platte River (bdc6.0), the Big Dry Creek average nitrate concentrations were below 10 mg/L with an average concentration of 6.6 mg/L during 2007, which is comparable to previous years. All values at bdc6.0 were below 10 mg/L during 2007. Figure 13 also shows that the average monthly grab samples from the Broomfield (bdc10.0) and Westminster (bdc11.0) wastewater discharges are higher than the downstream drinking water standard; however, dilution from stream flows and natural losses associated with the nitrogen cycle result in lower concentrations at the confluence with the South Platte River. Additionally, no samples from Northglenn's WWTP effluent were included in the 2007 analysis because Northglenn did not discharge to Big Dry Creek in 2007 during BDCWA sampling events, but this may change in the future and could influence concentrations at bdc6.0.

Phosphorus

The Barr-Milton Watershed Association (BMW) is addressing pH exceedances in the Barr-Milton reservoir system. These pH exceedances are attributed to excessive algal growth from nutrient loading. BMW has established a database for modeling conditions in the reservoirs and has included water quality data from Big Dry Creek, as well as many other tributaries upstream of the Barr-Milton system. Since most Front Range reservoirs with these types of concerns have ultimately been assigned either a total phosphorus or chlorophyll-a standard, phosphorus data collected during 2007 for Big Dry Creek have been plotted on Figure 14 for general reference. For purposes of a general frame of reference, WWTPs discharging to Front Range reservoirs such as Chatfield, Bear Creek and Cherry Creek have total phosphorus discharge limits ranging from 0.2 to 1 mg/L in their discharge permits.

Temperature

At the January 2007 CWQCC Rulemaking Hearing, the CWQCC adopted new temperature standards that became effective on July 1, 2007. However, temporary modifications to this standard were also adopted for certain stream types. Because Big Dry Creek is in the South Platte River Basin in a warm water stream, temporary temperature standards of 30 degrees C will be in place until December 31, 2009; however, more restrictive standards will potentially apply in the future, with potential implications for WWTP discharges on Big Dry Creek, with the winter months being of primary concern. Figures 15 and 16 show how 2007 temperatures compare to standards that may be applied to Big Dry Creek in the future. Temperature standards vary based on the warm water

biota present in the creek. It is not known which temperature standards would be applied to Big Dry Creek. For example, the "other ss" standards would appear to apply based on the on-going presence of longnose dace, creek chub, white sucker and brook stickleback in the creek. More stringent standards are required under the "cs, Jd, od" classification, where Jd indicates Johnny darters. Only one Johnny darter has been collected on Big Dry Creek since 2002; it was located upstream of the wastewater treatment plants at bdc1.0; therefore, it is unclear whether the more stringent "cs, Jd, od" classification would apply. More detailed analysis of the implications of the temperature standards will be needed in the future due to potentially significant implications to WWTP dischargers on the creek. One provision of the temperature standards that could be worth exploring for Big Dry Creek includes the following:

> *No temperature effluent limit will be applied if a discharge is to an effluent dependent stream and there is no evidence that the aquatic life use may be negatively affected by the thermal component of the discharge. In implementing this provision, the Division will consider all readily-available and pertinent evidence regarding the potential for the thermal properties of a discharge to affect aquatic life.*

Additional temperature monitoring is needed in the vicinity of the WWTP discharges on Big Dry Creek, along with an integrated review of fish sampling conducted to date on Big Dry Creek. Both the Broomfield has recently installed temperature probes upstream and downstream of their discharges for this purpose, and Northglenn and Westminster are in the process of completing a similar effort.

Mercury

All samples analyzed for mercury had results below detection limits during 2007. In 2008, BDCWA will be changing its monitoring approach for mercury using the USEPA 1631e analysis method at one monitoring location at 120th Avenue. This analysis method has much lower detection limits, providing more meaningful data, but also much more costly, thus the reason for limiting the analysis to one location.

Flow

The available USGS flow data for the Westminster and Fort Lupton gauges during 2007 are shown in Figures 17a and 17b. During 2007, average daily flows at the Westminster gauge ranged from 1.3 cubic feet per second (cfs) to 229 cfs with an average of 14 cfs. Average daily flows for the Fort Lupton gauge data ranged from 3 cfs to 360 cfs with an average of 35 cfs. During April 24-25, a large storm event occurred covering much of the watershed. Reported precipitation in various portions of the watershed included: 1.75 inches in Broomfield, 2.5 inches in Westminster, 2.1 inches in Thornton and 2.4 inches in Northglenn. As a result, flows in Westminster averaged 229 cfs on April 24, 2007 and in Fort Lupton, averaged 360 cfs on April 25, 2007 (Figures 18a and 18b). For the period of record at both gages since 1991, these April flows were in the top ten highest flows measured at these gages. For comparison, the April 24 flows exceeded the July 2004 flows that were studied in the Lower Big Dry Creek Hydrologic Study (WWE 2005).

As part of data exploration and research in support of the selenium hearing in December 2007, the complex nature of the hydrologic conditions on Big Dry Creek was recognized. This was an important reminder that the influence of these complex flow conditions should not be underestimated with regard to water quality, aquatic life and habitat conditions. Although a comprehensive assessment of the intricacies of the flow conditions on Big Dry Creek has not been completed as part of this memorandum, several representative concepts that should be kept in mind during analysis related to water quality and aquatic life include the following:

- Standley Lake Releases: Figure 19 shows available Standley Lake release data for the ten year period covering 1996 through 2005. The graph illustrates the variation in release patterns over the calendar year over time. For example, historically, from January through mid-April, Standley Lake is typically not releasing, and when it has released flows, these flows have historically been under 10 cfs. Similarly, releases have historically been low in the October to December timeframe; however, due to changes in operation of Northglenn's augmentation plan in recent years, flows in the 10 to 30 cfs range have occurred with greater frequency in the late fall and early summer. Releases during the irrigation season vary substantially on any given day.

- Effect of Releases and Diversions on Instream Flows: Although two USGS gaging stations are in place on the creek, they do not necessarily capture the variation of flow conditions in various reaches of the stream. For example, as shown in Figure 20, Standley Lake releases significant flows each year, but much of these flows are only in the stream until they reach the Bull Canal, where significant diversions occur, just upstream of the Westminster WWTP. Additional diversions on the creek include the Thorn Creek Golf Course below I-25, the German Ditch near 136th and Washington, the Thompson Ditch upstream of the Northglenn WWTP discharge, the Yoxall Diversion below Northglenn's discharge, and the Lupton Bottoms Ditch, located between the USGS gage near Fort Lupton and the confluence with the South Platte. Smaller diversions also occur such as for City Park Pond and Community College Lake in Westminster. During biological sampling on several occasions, Aquatics Associates has noted that nearly all of the flow at some monitoring locations is diverted from the creek at various times.

- Wastewater Reuse: Both Broomfield and Westminster are actively implementing reclaimed water programs, which have the effect of decreasing instream flows at various times. These changes are also important to note when evaluating Big Dry Creek hydrology and water quality.

- Stormwater: The central portion of the watershed continues to urbanize, which inevitably alters stream hydrology. Implementation of stormwater quality and quantity detention practices in accordance with Urban Drainage and Flood Control District (UDFCD) standards and master plans continues to be essential for stream stability, water quality and public safety reasons. Local governments within the Big Dry Creek watershed continue to work with UDFCD on planning, design and implementation of drainage and water quality improvements.

Quality Assurance/Quality Control

During 2007, quality assurance/quality control (QA/QC) procedures were followed for the sampling program in accordance with the Big Dry Creek Sampling and Analysis Plan (BDCWA 2003). Under this program, field blanks are analyzed for the full suite of constituents in March, a full set of duplicate analyses are completed in September, and during June and December, field duplicates are analyzed for four locations (bdc1.5, bdc2.0, bdc3.0 and bdc5.0) for constituents of concern (selenium, *E. coli*, ammonia and iron).

Table 3 summarizes analysis of field blank and duplicate samples for 2007. Analysis of relative percent difference (RPD) for the sample duplicates generally shows acceptable accuracy for most constituents. Exceptions and several results requiring explanation include:

- Total recoverable iron results had relatively high RPD percentages, averaging 48% for three replicate pairs. Reported values for the sample pairs were well above detection limits and in some cases above the stream standard, as well. A possible explanation for this result could be the fact that iron is strongly associated with TSS in the stream. Per the sampling plan, field duplicates are prepared by collecting identical sample aliquots…;" however, the likelihood is that the underlying samples are not identical due to the natural variation of sediment in the samples. Care should be taken with regard to sampling procedures to ensure that the replicate samples are as similar as possible and that bottom sediments are not being stirred up and captured during sampling. Due to the "bucket sampling" approach at bdc5.0, it is particularly important to take care to ensure that the samples are representative of conditions in the stream.

- Several of the dissolved metals (arsenic, cadmium, copper) showed higher RPD values (e.g., 25-30%) than other constituents, primarily in the September 13 sample at bd5.0. Some variation in dissolved metals can occur in unfiltered, preserved samples due to some leaching from sediment in the sample. Therefore, careful sampling, as suggested above, is important.

Field blank analyses were within acceptable concentrations with the exception of copper and manganese. Copper (0.8 µg/L) was an order of magnitude above the detection limit (0.08 µg/L) and manganese (0.8 µg/L) was four times the detection limit (0.2 µg/L). Neither of these analytes are constituents of concern. Possible explanations could be the potential presence of metals in the preservatives in the trip blanks.

It appears that there was some confusion during 2007 regarding which constituents should be analyzed at each location on which date for QA/QC purposes. For example, in September at bdc5.0, it appears that duplicate samples were inadvertently not collected for eight constituents (e.g., TSS, total ammonia and several others). Conversely, unnecessary sample analysis for duplicates was also completed for some constituents. Care should be taken to include the full suite of constituents specified in the monitoring plan in future monitoring efforts. Table 4 from the sampling and analysis plan is provided below.

Field Quality Control Program (from 2004 monitoring plan)

Month	QC Test	Site
March	Field blanks (complete set)	6.0 (represents max equipment use)
June	Field duplicates for Constituents of Concern (Represents high flows)	1.5 – Selenium 2.0 – *E. coli* 3.0 – NH_3 5.0 – Fe (TRec)
September	Field duplicates, full set	5.0 –most constituents detected at this site.
December	Field duplicates for Constituents of Concern (Represents low flows)	1.5 – Selenium 2.0 – *E. coli* 3.0 – NH_3 5.0 – Fe (TRec)

Recommendations

1. The BDCWA should continue to monitor *E. coli* conditions along the creek and participate in regional efforts to better understand non-point sources of bacteria and potential approaches to address these sources. Given the "high" priority status of bacteria on the 2008 303(d) List, the BDCWA should continue to move forward with plans to conduct field investigations and collect samples in areas of consistently high bacteria, such as the reach of stream between bdc2.0 and bdc3.0. Study of this reach of stream will result in the completion of the *E. coli* study for the entire urban reach of Big Dry Creek with elevated *E. coli* concentrations. General recommendations for this analysis include:

    - Collect samples between bdc2.0 and bdc3.0 in general accordance with the sample guidance used for the bdc1.0 to bdc2.0 study (WWE 2007). (This guidance was adapted from the CWQCD sample guidance for the South Platte River Segment 14, dated February 15, 2007.)

    - Coordinate dry weather sampling events between bdc2.0 and 3.0 with municipal stormwater permit holders, who have mapped outfall locations to Big Dry Creek.

    - Integrate these findings with the first phase study between bdc1.0 and bdc2.0.

    - Remain involved with the Water Quality Forum *E. coli* Work Group on this issue to ensure consistency with approaches being implemented on comparable streams on the 303(d) List.

2. The following changes to the Big Dry Creek Sampling Plan are recommended for immediate implementation (in addition to changes already identified in December 2007, such as the mercury sampling change):

   Monitoring Frequency Increase:

   - Reinstate monthly instream monitoring program for dissolved selenium through August 2008, reverting to the quarterly monitoring program for metals in September 2008. *(This change will enable five complete irrigation season data sets, whereas the originally envisioned quarterly program does not.)*

   Deletion of Specific Analyses:

   - Delete *Dissolved* Arsenic (the standard is Total Recoverable, which BDCWA is already monitoring)

   - Delete *Dissolved* Iron (the standard is Total Recoverable, which BDCWA is already monitoring)

   Monitoring Frequency Reduction:

   - Decrease *Total Recoverable* Iron to quarterly (Big Dry Creek is no longer on the Monitoring and Evaluation List for iron, per the 2008 303(d) List). (As a result, all metals will be on a quarterly schedule, other than selenium through July 2008.)

3. WWE recommends continued participation in temperature and nutrient criteria work groups under the umbrella of the Water Quality Forum.

4. WWE recommends no further special studies regarding selenium, with the possible exception of biennial fish tissue analyses, which should be discussed in the fall 2008.

REFERENCES

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TABLES

FIGURES

ATTACHMENT